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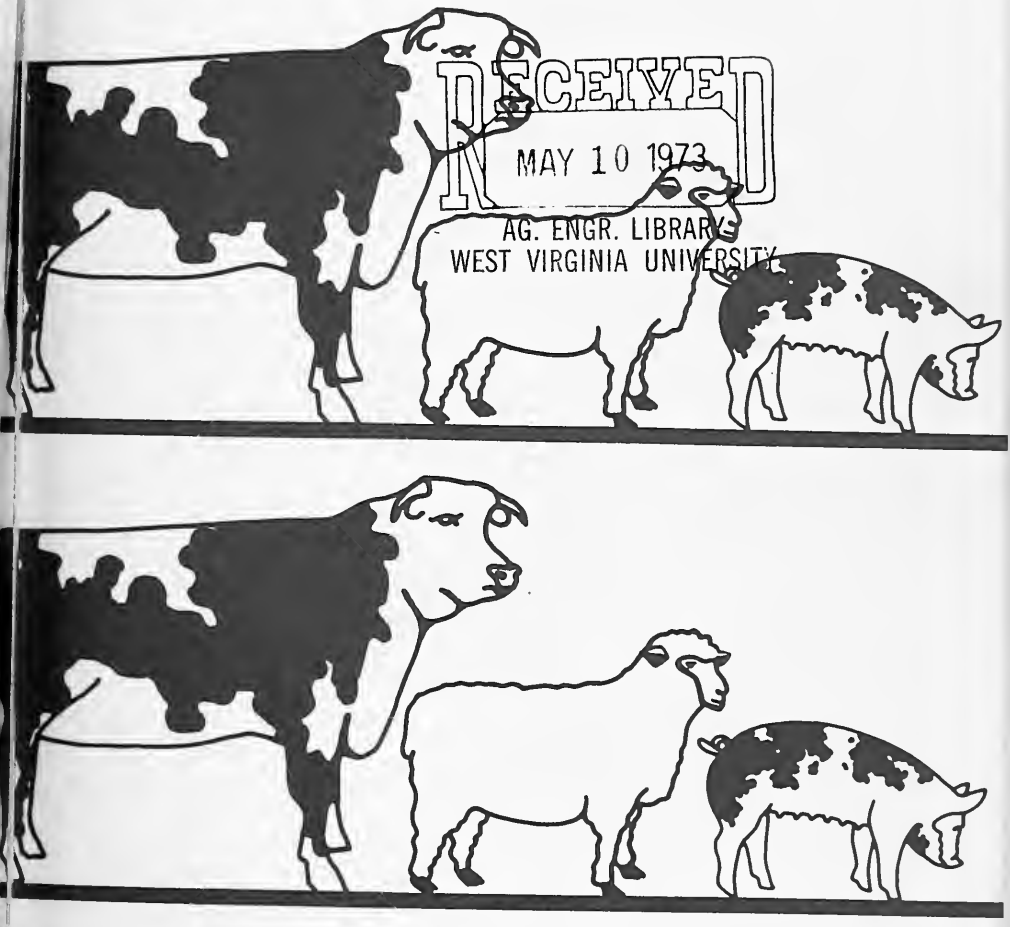

Vest Virginia University Agricultural Experiment Station

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Optimum Number, Size and Location of Livestock Auction Markets in West Virginia

John P. Kuehn

INTRODUCTION AND OBJECTIVES

A livestock marketing research program conducted by the West Virginia Agricultural Experiment Station has been designed as a series of analyses, each study contributing to its successor in a building block fashion.

The first study in the series examined the characteristics of the State's livestock auction markets in terms of auction procedures, livestock volumes, and operating costs,[1] finding that the larger auctions in West Virginia, in terms of annual volume, "enjoyed distinct cost advantages over the smaller firms. . ."[2]

The second study in the series constructed or engineered three different sized *model* livestock auctions.[3] These model auctions were designed to be "efficient" with regard to operating practices and costs, and were compared to the actual auctions operating in the State.[4] Given the existing volume of livestock marketed through auctions, "actual unit costs were similar to the engineered costs which were defined as efficient."[5] "The average revenue per animal unit marketed through livestock auctions. . .was lower than the average cost per animal unit for the average of West Virginia auction markets."[6] The conclusions: since the actual auctions in the State are apparently operating efficiently under present economic conditions, they could decrease their unit costs only through an increase in the number of animals marketed through them; and, since on an aggregate basis, revenue was lower than costs, it is almost inevitable that the less efficient auctions will cease operating, allowing the remaining markets to increase their annual volumes, and thereby decrease costs.[7]

[1]Wilson, E. M. and J. P. Kuehn, "A Cost Analysis of The Livestock Auction Markets in West Virginia," WVU Ag. Exp. Sta. Bull. 600T, April, 1971.

[2]*Ibid.*, p. 4.

[3]Kuehn, J. P., "Costs and Efficiencies of Model Livestock Auctions in West Virginia," WVU Ag. Exp. Sta. Bull. 606, December, 1971.

[4]*Ibid.*

[5]*Ibid.*, p. 3.

[6]*Ibid.*

[7]*Ibid.*

The third study in the series analyzed the prices and volumes of livestock sold in West Virginia auction markets.[8] Seasonal variation in marketings and prices as well as the effects of inflation on livestock prices were examined.[9] The most recent analysis determined the costs of livestock transportation in the State,[10] and concluded that farmers transporting relatively small volumes of livestock on small farm trucks realized much higher costs per animal transported than large operations.[11]

The next step in the livestock marketing research program would logically be to determine how many auctions are necessary in West Virginia, considering the annual volume of livestock sold, how large these auctions should be and where they should be located—the objective of this study. Three different levels of transportation costs and three different levels of annual marketings of livestock will be analyzed.

THEORY AND PROCEDURE

The model used to accomplish the objectives of this study was developed by Stollsteimer[12] and later modified by Polopolus,[13] and assumed that all animals sold in the State would be sold through livestock auctions. Due to restrictions in the model, it was also necessary to assume that auction market selling costs would be the same throughout West Virginia regardless of where an auction was to be located. Also, the model is concerned only with the costs and procedures involved in transporting cattle, calves, hogs, and sheep and lambs to auction markets and the costs involved in selling these animals. Costs and procedures taking place after the sales at auction markets were not considered in this study.

The model basically minimizes the sum of two cost functions: (1) total transportation costs and (2) total selling costs. Transportation costs are lower in regions with a large number of destinations (auction markets) than regions with a few destinations. The greater the number of auction markets in a region, the

[8]Golden, Paul D. and John P. Kuehn, "Prices and Volumes of Livestock Sold in West Virginia Auction Markets, 1960-1969," WVU Ag. Exp. Sta. Bull. 607, March, 1972.

[9]*Ibid.*

[10]Lin, C. F. and J. P. Kuehn, "Livestock Transportation Costs in West Virginia," WVU Ag. Exp. Sta. Bull. 613, January, 1973.

[11]*Ibid.*

[12]Stollsteimer, John F., "A Working Model for Plant Numbers and Location," *Journal of Farm Economics,* Vol. 45, No. 3, August, 1963, pp. 631-645.

[13]Polopolus, Leo, "Optimum Plant Numbers and Locations for Multiple Plant Processing," *Journal of Farm Economics,* Vol. 47, No. 2, May 1965, pp. 287-295, and Chern, Wen-Shyong, and Leo Polopolus, "Discontinuous Plant Cost Functions and a Modification of the Stollsteimer Location Model," *American Journal of Agricultural Economics,* Vol. 52, No. 4, November, 1970, pp. 581-586.

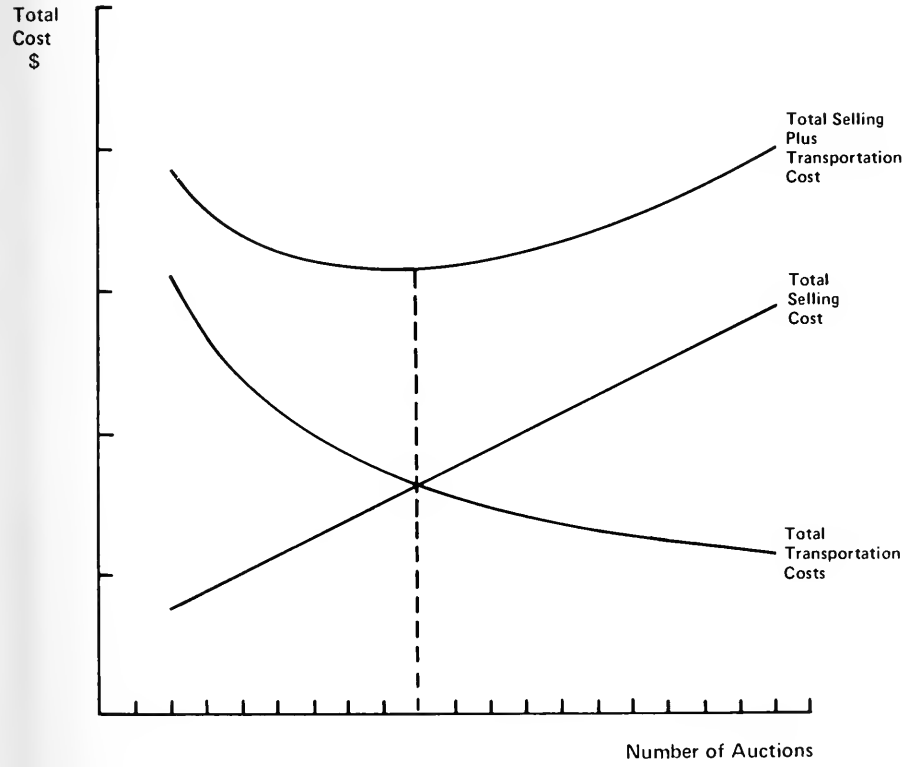
shorter the distance farmers must travel to bring their livestock to market. Selling costs, on the other hand are higher in regions with a large number of auction markets than in regions with a few markets. The greater the number of auction markets in a region with a given annual volume of livestock for sale, the fewer the number of animals available to be sold at each market. And auction markets selling low volumes of livestock incur higher costs than larger auctions.

In effect, the computer model[14] determines the number, size, and location of auction markets by minimization of the sum of total transportation and total selling costs (Figure 1). In an iterative process the program allocates, in a least

[14]The Computer program was supplied by Leo Polopolus, University of Florida.

Figure 1

Minimization of Total Selling and Total Transportation Costs



Source Adapted from Stollsteimer, John F., "A Working Model for Plant Numbers and Locations", *Journal of Farm Economics*, Vol 45, No 3, August, 1963, p 637.

configuration, all the livestock from each origin (West Virginia county) to each combination of destinations (auction markets) until total transportation costs plus selling costs are minimized. The program then specifies which origins supply livestock to each of the optimal number of destinations chosen from the set of all possible destinations, and it specifies the transportation and selling costs associated with the solution.

The three main factors which influence the optimum number, size, and location of auction markets are transportation costs, the number of animals marketed, and selling costs. In order to gain a better understanding of the nature of the State's livestock industry by means of this model, two of these factors were varied. Three different levels of transportation costs per animal unit per mile and three levels of annual marketings of livestock in the State were used to determine alternative optimum solutions. Auction market selling costs varied depending on the size of market chosen by the computer program.

ORIGINS

Each of the 55 counties of West Virginia was entered into the model as an origin. In order to determine the transportation costs, which are based on the shortest highway mileage from origin to destination, the approximate center of each county was assumed to be the point from which livestock were transported.

The number of cattle, calves, hogs, and sheep and lambs sold from each county was taken from the 1969 census of Agriculture.[15] In the 1969 census, however, the cattle sold by county were not separated from the number of calves sold, as they were in the 1959 and 1964 censuses. These two categories were separated by the following method: (1) The number of cattle as a percentage of the sum of cattle and calves sold was determined for each county in 1959 and in 1964; (2) These two annual figures were averaged for each county; and (3) The resulting average percentages were then applied to the 1969 total of cattle and calves sold to provide an estimate of the number of cattle and calves sold by county in 1969.

The computer model is based on the assumption that all livestock, regardless of species, from a particular origin are transported to one destination. The cattle from an origin, for example, cannot be transported to one particular destination and the calves taken to another. Therefore, for purposes of simplification, the different species were converted into homogeneous animal units. The conversion of the species into common animal units "was based on the space requirement of cattle of 20 square feet each, calves ten square feet each, and hogs, sheep and lambs five square feet each."[16] Therefore, one "cattle" was equivalent to two

[15] 1969 Census of Agriculture, U. S. Bureau of the Census, Volume 1, Area Reports, Part 25, West Virginia, Section 2, County Data, U. S. Government Printing Office, Washington, D.C., 1972.

[16] Kuehn, John P., "Costs and Efficiencies of Model Livestock Auctions in West Virginia", WVU Ag. Exp. Sta. Bull. 606, December, 1971, p. 6.

calves which were equivalent to four hogs or four sheep or lambs. This 1:2:4:4 ratio was used to convert cattle, calves, hogs, and sheep and lambs to animal units by county in West Virginia (Table 1). Figure 2 displays the distribution of animal units by county.

DESTINATIONS

The computer program limited the number of possible destinations or auction market sites to 15. However, 18 auctions were operating in West Virginia in 1972.[17] Therefore, three market sites were eliminated from consideration in this study. Fifteen of the 18 possible sites were chosen based on three criteria: (1) the geographical location of the market in relation to other markets; (2) the livestock production density in the county where a market is located; and (3) the size of the market in terms of the annual number of animal units sold.[18]

The destinations or potential auction market sites, chosen for analysis, were located in the approximate centers of the counties where the 15 existing markets are located. An objective of this study was to determine the nature of marketing practices in the State in terms of general directions of movements and trends. Therefore, it was unnecessary to specifically consider the existing auction markets in arriving at meaningful conclusions.

The potential destinations or auction market sites used for this analysis were the following:

County	City
1. Marshall	Glen Easton
2. Wood	Mineral Wells
3. Jackson	Ripley
4. Roane	Gandeeville
5. Mason	Southside
6. Lewis	Weston
7. Harrison	Clarksburg
8. Marion	Fairmont
9. Preston	Kingwood
10. Randolph	Valley Bend
11. Pocahontas	Edray
12. Greenbrier	Frankford
13. Raleigh	Beckley
14. Hardy	Moorefield
15. Jefferson	Charles Town

[17] Eighteen auctions reported to the West Virginia Department of Agriculture in Charleston in 1972.

[18] The markets which were eliminated were not listed in this study in order to maintain the confidential nature of annual reports of livestock auctions to the West Virginia Department of Agriculture. Multiple runs considering other combinations of the 18 existing auctions did not affect the conclusions for this variant of the model.

TABLE 1

The Number of Cattle, Calves, Hogs, and Sheep and Lambs Sold by County, West Virginia, 1969 and the Equivalent Number of Animal Units for Each County[a]

County	Cattle	Calves	Hogs	Sheep & Lambs	Animal[b] Units
Barbour	2,443	4,324	310	993	4,931
Berkeley	2,752	4,471	7,552	793	7,074
Boone	43	47	40	7	79
Braxton	1,805	3,632	449	3,627	4,640
Brooke	401	542	101	318	776
Cabell	735	1,257	451	114	1,505
Calhoun	1,009	1,639	128	403	1,962
Clay	365	505	23	839	833
Doddridge	1,188	1,602	623	1,710	2,573
Fayette	381	1,020	536	539	1,160
Gilmer	842	2,021	437	1,576	2,355
Grant	2,627	3,642	3,969	10,120	7,900
Greenbrier	8,571	9,627	1,687	10,056	16,321
Hampshire	3,737	7,033	7,474	4,278	10,190
Hancock	121	118	6	60	197
Hardy	3,887	6,003	18,214	13,406	14,793
Harrison	3,972	4,462	240	1,587	6,660
Jackson	2,374	4,651	1,078	1,314	5,298
Jefferson	6,365	8,473	8,306	1,293	13,000
Kanawha	439	635	206	0	807
Lewis	3,118	5,108	457	4,229	6,843
Lincoln	235	489	53	10	496
Logan	11	8	4	0	16
McDowell	—c—	—c—	—c—	—c—	—c—
Marion	1,016	1,964	560	666	2,304
Marshall	1,750	3,167	1,967	4,013	4,828
Mason	4,074	6,008	4,865	870	8,511
Mercer	1,592	2,335	387	1,151	3,144
Mineral	1,328	2,392	2,063	3,450	3,902
Mingo	4	5	54	0	20
Monongalia	1,822	2,475	680	3,033	3,988
Monroe	6,250	7,763	2,486	9,244	13,063
Morgan	406	890	702	30	1,034
Nicholas	1,211	1,639	331	1,511	2,491
Ohio	647	1,475	572	399	1,627
Pendleton	5,296	7,405	10,506	27,054	18,388
Pleasants	241	764	788	103	840
Pocahontas	2,190	4,527	1,564	22,545	10,480
Preston	2,984	5,818	9,448	2,751	8,943
Putnam	1,026	1,856	570	473	2,214
Raleigh	876	1,400	808	1,154	2,060
Randolph	2,778	4,382	975	10,426	7,815

TABLE 1 (continued)

County	Cattle	Calves	Hogs	Sheep & Lambs	Animal [b] Units
Ritchie	1,857	2,786	129	1,783	3,728
Roane	3,407	4,963	817	1,503	6,469
Summers	1,317	1,669	527	1,444	2,644
Taylor	1,503	2,330	450	1,026	3,036
Tucker	781	1,682	554	1,814	2,213
Tyler	917	1,660	517	534	2,010
Upshur	2,054	4,280	292	1,506	4,643
Wayne	454	734	320	125	932
Webster	291	539	59	446	687
Wetzel	586	993	295	2,098	1,680
Wirt	1,220	1,815	612	763	2,472
Wood	2,051	2,787	2,433	919	4,283
Wyoming	77	137	14	46	161
TOTAL	99,427	153,949	98,689	160,152	241,035

[a]Source: 1969 Census of Agriculture, U. S. Bureau of the Census, Volume I, Area Reports, Part 25, West Virginia, Section 2, County Data, U. S. Government Printing Office, Washington, D. C., 1972.

[b]One animal unit was equivalent to one cattle or two hogs or four hogs or four sheep or lambs.

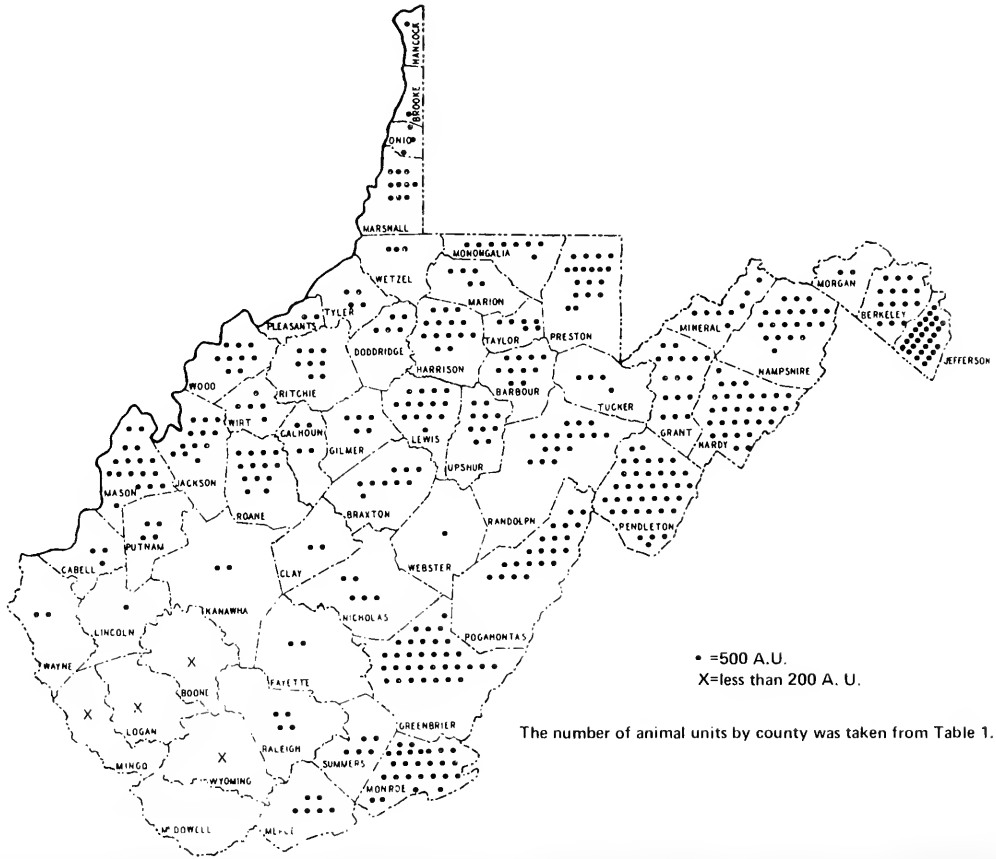
[c]According to the U. S. Census of Agriculture (citation "a" above), "McDowell County, W. Va., was not shown separately to avoid disclosing data for individual farms." It was therefore assumed that no animals were sold in McDowell County in 1969 based on the judgment that the numbers sold in 1959 and 1964 were not a significant enough quantity to affect the results of this analysis.

TRANSPORTATION COSTS

Transportation costs were a function of the highway mileage from the farm to the auction market. In order to obtain an estimate of the total transportation bill, costs per animal unit transported per mile were mulitplied by the roundtrip mileage from the origin county to the potential market site. Since farmers who transport their own livestock to market also have to return to their farms, the return trip should also be considered in cost calculations. Highway mileages were determined from the approximate centers of each of the 55 counties to the approximate centers of each of the 15 market sites. In the cases where a county was also a potential market location, livestock in that county traveled an assumed average of 15 miles to that market or 30 miles round-trip.

The transportation costs per animal unit per mile were taken from a recent livestock transportation study in West Virginia.[19]

[19] Lin, Chen-fen, and John P. Kuehn, "Livestock Transportation Costs in West Virginia," WVU Ag. Exp. Sta. Bull. 613, January, 1973.



The number of animal units by county was taken from Table 1.

Figure 2. The Distribution of Animal Units of Livestock Sold by County, West Virginia, 1969

Three assumptions concerning the type of transportation means involving three different unit transportation costs were examined in the analysis to determine the effects of variations in transport practices:

1. *Farm Truck Transportation.* A large number of farmers in West Virginia bring their livestock to market in small farm trucks, according to interviews with farmers, auction owners, and experiment station personnel. The model cost situation that most closely approximates this actual transportation practice was taken from Lin and Kuehn.[20] The first computer run of the model assumed all animals would be transported by means of a 1/2-ton fully loaded (capacity = two animal units) truck and that this truck traveled 1,000 miles per year carrying livestock and that the truck was used for other farm purposes when not carrying livestock. Fixed costs of transportation were therefore assigned to just 1,000 miles for one month per year while the remainder of the fixed costs was assigned to "other farm uses" during the remaining 11 months. The cost per animal unit per mile for these assumptions was $0.0817.[21]

2. *Hired Truck Transportation.* According to the same interviews, it was found that some farmers hire outside trucking companies to transport their livestock. The cost situation from Lin and Kuehn which most closely approximates the cost of hired truck transportation was that of a 1 1/2-ton fully loaded (capacity = 10 animal units) truck. It was assumed that this truck traveled 1,000 miles for a one-month period transporting livestock, with fixed costs spread out for other uses during the 11 off-months. The cost per animal unit per mile for these assumptions was $0.0199.[22]

3. *One-half Farm Truck and One-half Hired Truck Transportation.* The third run of the model examined the assumption that half of the livestock sold would be transported by farm trucks and the other half by hired truck transportation. The rate used for this run of the computer model was $0.0508 per animal unit per mile, which was one-half the difference between the unit costs in assumptions one and two above.

AUCTION MARKET COSTS

Computer model specifications required that auction costs per animal unit sold be the same at all locations. The average variable selling cost would be the same regardless of the number of auctions in operation or the number of animal units sold. This average variable selling cost, therefore, had no influence on the optimum solution.

Fixed selling costs or the cost of building and maintaining a market did influence the optimum solution. The computer model, in effect, "built" new

[20] *Ibid.*

[21] *Ibid.*, p.16. This source presents a more complete discussion of how these costs were derived.

[22] *Ibid.*, p.18.

auctions until the sum of the transportation cost functions and the selling cost functions were minimized. The fixed selling cost used in this model was taken from Kuehn.[23] The components of fixed selling costs for a model livestock auction selling 27,720 animal units annually included: building depreciation, equipment depreciation, insurance, taxes, and interest. The total fixed or investment costs amounted to $24,423.00 per annum.[24]

The investment costs for an auction market of this size (1,500 animal units daily capacity processing 27,720 animal units per year) was used in the model to reflect economies of size. Auctions processing more than 27,720 animal units per year would have lower average total selling costs and auctions selling less than 27,720 animal units per year would incur higher average total selling costs than this auction market.

The fixed cost of $24,423.00 was used for the computer model in determining the optimum number of markets. However, more realistic selling costs were determined for the State after the computer model solution was obtained. The optimum solution specified the number of auctions required and the number of animal units which would be sold by each. Fixed and variable costs were then assigned to each of the markets in the final solutions. These fixed and variable costs were different depending on the annual turnover of livestock specified by the computer model.[25]

ANALYSIS

The computer model for determining the optimum number, size, and location of auction markets was run a total of nine times. Optimal configurations were determined for two sets of assumptions: (1) a variation of 25 per cent above and below the actual numbers for 1969 in the annual number of animal units marketed; and (2) optima for three levels of transportation cost per animal unit per mile. These rates were based on the assumptions that all animals would be transported by farm trucks; half of all animal units would be marketed by farm truck and half by hired truck; and all animal units marketed would be carried by hired trucks.

Table 2 presents total and per unit selling and transportation costs and the optimum number of auctions for each of the nine solutions. Table 3 shows the optimum sizes of the auctions selected and the cost per animal unit sold in each of the auctions assuming the three levels of transportation cost. Figures 3, 4, and 5 show the counties served by each of the auctions in Table 3. Appendix Table 1

[23] Kuehn, *op. cit.*, p. 31.

[24] *Ibid.*

[25] Costs per animal unit sold by auctions specified by the computer model were taken from a cost analysis of efficient auction markets assumed to be operating in West Virginia, Kuehn, *Ibid.*, p. 34.

Optimum Number, Selling and Transportation Total and Per Unit Costs of Livestock Auctions Assuming Three Levels of Livestock Sold Annually and Three Levels of Transportation Cost

Type of Transportation	Number of Livestock Sold: 25 Per Cent Below (180,784 Animal Units) Total Cost	25 Per Cent Below (180,784 Animal Units) Cost Per Animal Unit Sold	Actual Number Sold (241,035 Animal Units) Total Cost	Actual Number Sold (241,035 Animal Units) Cost Per Animal Unit Sold	25 Per Cent Above (301,299 Animal Units) Total Cost	25 Per Cent Above (301,299 Animal Units) Cost Per Animal Unit Sold
Farm Truck (1/2-ton)	(12 Auctions)		(13 Auctions)		(13 Auctions)	
Selling Cost[a]	$631,838.06	$3.50	$ 798,488.13	$3.31	$ 927,712.48	$3.08
Transportation Cost[b]	737,549.00	4.08	952,223.00	3.95	1,190,302.00	3.95
Total Cost	1,369,387.06	7.58	1,750,711.13	7.26	2,118,014.48	7.03
Half Farm Truck and Half Hired Truck	(10 Auctions)		(11 Auctions)		(12 Auctions)	
Selling Cost[a]	596,967.47	3.30	752,263.53	3.12	895,101.19	2.97
Transportation Cost[b]	446,836.00	2.75	633,811.00	2.63	764,334.00	2.54
Total Cost	1,093,803.47	6.05	1,386,074.53	5.75	1,659,435.19	5.51
Hired Truck (1 1/2-ton)	(6 Auctions)		(6 Auctions)		(8 Auctions)	
Selling Cost[a]	505,616.01	2.80	639,705.92	2.65	811,899.73	2.69
Transportation Cost[b]	250,279.00	1.38	333,694.00	1.38	363,876.00	1.21
Total Cost	755,895.01	4.18	973,399.92	4.03	1,175,775.73	3.90

[a]Processing or selling costs were taken from efficient model plants selling similar numbers of livestock annually to the auctions derived in the computer system, Kuehn, *Ibid.*, p. 34.

[b]Total transportation costs were derived by the computer program (mileage x transportation cost per animal unit per mile.) Transportation costs per animal unit sold were derived by dividing the total transportation cost by the total number of animal units sold.

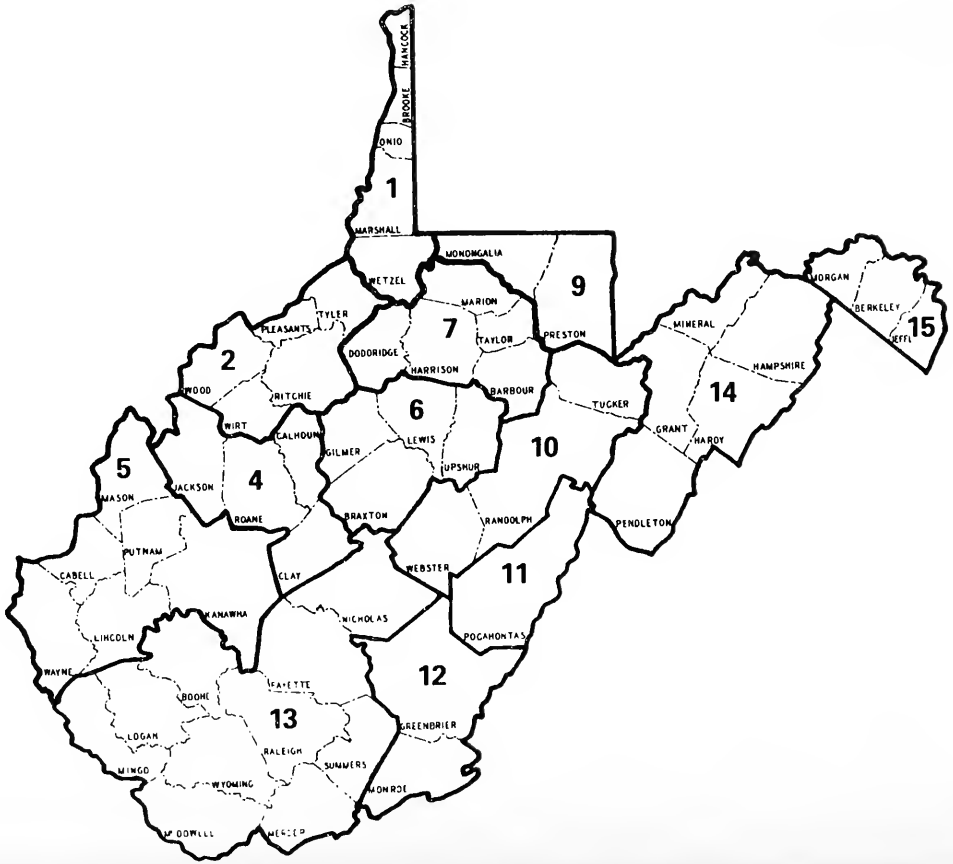


Figure 3. Optimum Market Locations and the Counties Served by Each Auction, Assuming all Animal Units are

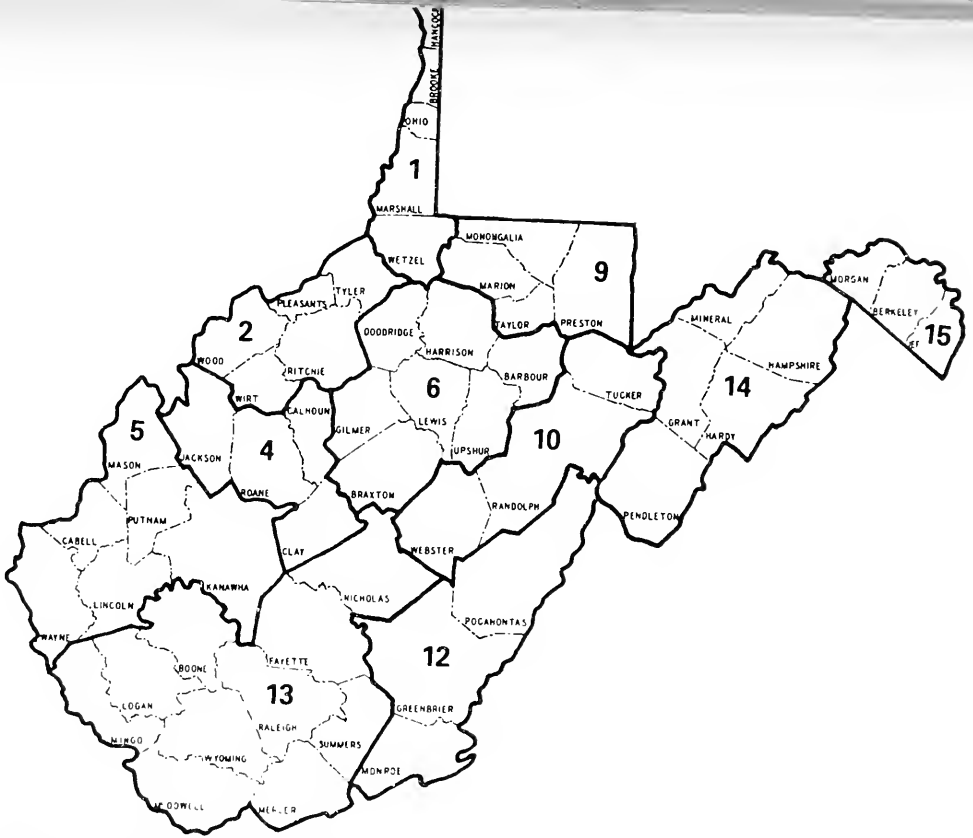


Figure 4. Optimum Market Locations and the Counties Served by Each Auction, Assuming Half of all Animal Units are Transported by Farm Truck and Half are Transported by Hired Truck

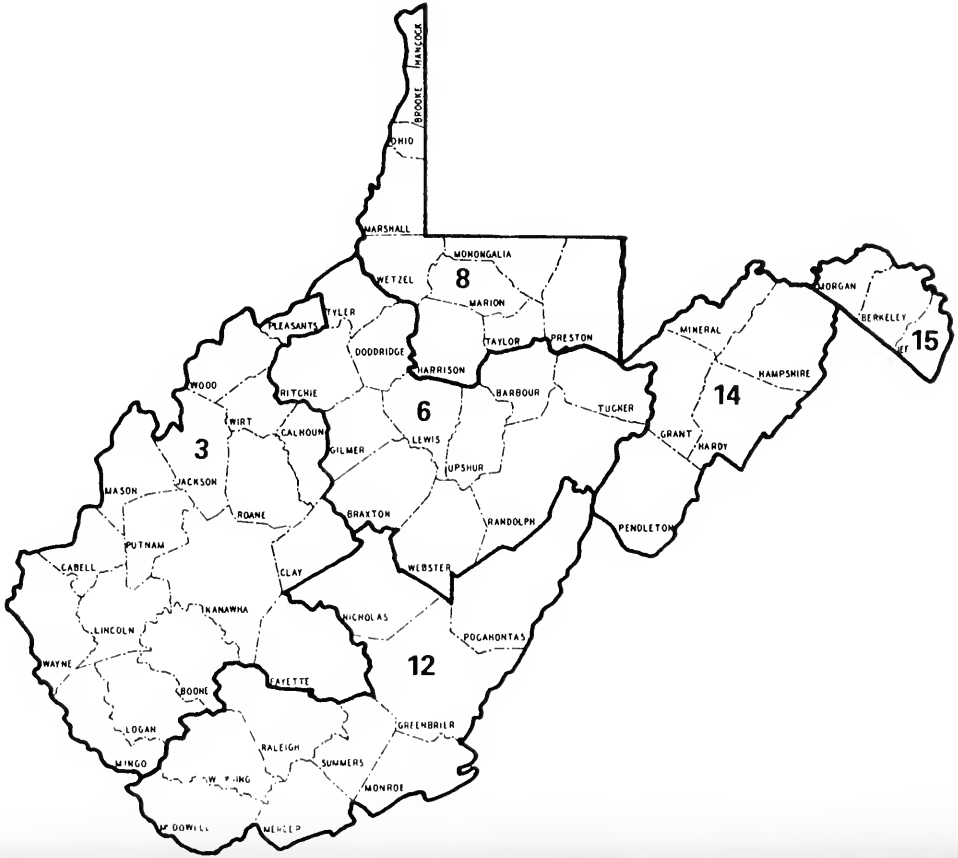


Figure 5. Optimum Market Locations and the Counties Served by Each Auction, Assuming all Animal Units

presents the optimum sizes of the auctions selected and the cost per animal unit sold in each of the auctions assuming the three levels of transportation cost and assuming a 25 per cent increase in the total number of animal units marketed. Appendix figures 1, 2, and 3 show the counties served by this set of auctions. Appendix Table 2 presents the optimum sizes of auctions selected and the cost per animal unit sold in each of the auctions assuming the three levels of transportation cost and assuming a 25 per cent decrease in the total number of animal units marketed. Appendix figures 4, 5, and 6 show the counties served by this set of auctions.

Out of the 15 possible auction market locations, 13 were necessary for cost minimization assuming farmers transported their own livestock to market in 1/2-ton trucks. If half of these farmers utilized hired trucks or fully loaded 1 1/2-ton trucks, costs would be minimized with 11 auction markets. And if all farmers used hired truck transportation, only six auctions would be necessary for minimization of the combined transportation and selling costs on a statewide basis (Table 2). Total marketing cost (transportation plus selling cost) was $7.26 per animal unit sold if all farmers used farm trucks. This figure decreased to $5.75 for half farm truck use and half hired truck use, and $4.03 if all farmers hired transportation (Table 2).

The number of auctions required in the State generally increased as the number of animals sold increased. This number decreased, however, as the type of transportation used became more efficient and consequently less costly. Total costs per animal unit sold decreased as the number of animals produced and sold increased. Total cost per animal unit sold also decreased as more efficient means of transportation were used (Table 2).

The average size of the optimum number of livestock auctions (in terms of animal units sold annually) was 18,541 animal units at the 13 auctions if all farmers transported their own livestock in 1/2-ton pickups. This average size increased to 21,912 head per year in 11 auctions if half the State's farmers used 1 1/2-ton trucks fully loaded; and, if all farmers used 1 1/2-ton fully loaded trucks or hired similar transportation means, the average size of the six auction markets required for cost minimization would be 40,173 head per year. Selling costs in these cases would decrease from $3.31 per animal unit sold to $3.12 and to $2.65 as the average number of head sold per auction increased (Table 3).

Selling costs per animal unit sold would decrease 5.7 per cent if half of the producers hired trucks instead of taking their own animals to market. This decrease would be 19.9 per cent if all farmers used hired transportation. The total cost of marketing would decrease 44.5 per cent if all farmers used hired transportation in West Virginia, based on the assumptions of this model.

It can be seen from Figures 3, 4, and 5 that the areas served by auctions became wider as the transportation costs decreased. Auctions tended to be located in areas with high production densities when the less efficient forms of transportation were assumed to be used. When more efficient transportation means were used, the areas served by an auction became wider, but the auctions

TABLE 3

Optimum Sizes of Livestock Auction Markets in Terms of the Number of Animal Units Sold Annually and Selling Cost Per Animal Unit Assuming Three Levels of Transportation Cost

Location of Auction	Farm Truck (1/2-ton)		Half Farm Truck Half Hired Truck		Hired Truck (1 1/2-ton)	
	AU's Sold	Cost/AU[a]	AU's Sold	Cost/AU[a]	AU's Sold	Cost/AU[a]
Marshall	9,108	$4.27	9,108	$4.27	–	–
Wood	13,339	3.75	13,339	3.75	–	–
Jackson	–	–	–	–	37,903	$2.60
Roane	14,562	3.79	14,562	3.79	–	–
Mason	14,465	3.79	14,465	3.79	–	–
Lewis	18,481	3.46	32,645	2.73	42,442	2.50
Harrison	19,504	3.23	–	–	–	–
Marion	–	–	–	–	34,039	2.60
Preston	12,931	3.75	18,271	3.46	–	–
Randolph	10,719	4.00	10,719	4.00	–	–
Pocahontas	10,480	4.00	–	–	–	–
Greenbrier	29,384	2.82	39,864	2.55	50,370	2.66
Raleigh	11,781	3.90	11,781	3.90	–	–
Hardy	55,173	2.58	55,173	2.58	55,173	2.58
Jefferson	21,108	3.23	21,108	3.23	21,108	3.23
Total	241,035		241,035		241,035	
Average	18,541	3.31	21,912	3.12	40,173	2.65

[a]The selling costs per animal unit were taken from Kuehn, *Ibid.*, p. 34. They are the total costs per animal unit sold in auction markets of similar

nemselves were usually located in high production areas or centrally located etween areas with high production densities.[26]

Trends in auction market locations and sizes were generally the same when nnual marketings were assumed to increase and decrease 25 per cent. An ncrease in annual marketings of 25 per cent does not require an additional uction market based on the assumption that all farmers used farm trucks 1/2-ton pickups), but if half of these farmers used hired transportation, an extra uction would be required for statewide costs to be minimized. Two more uction markets would be required if all farmers used hired transportation means Appendix Table 1 and Appendix Figures 1, 2, and 3).

On the other hand, if annual marketings decreased 25 per cent, one less uction would be required if all farmers used 1/2-ton pickups and one less uction would be required if half of these farmers used hired transportation. If l farmers used hired transportation and output decreased 25 per cent, the umber of auctions required for total marketing cost minimization would not ecrease (Appendix Table 2 and Appendix Figures 4, 5, and 6).

SUMMARY AND CONCLUSIONS

The trend in West Virginia is toward fewer and larger livestock auctions, as ontrasted to the present large number of widely scattered, small-sized livestock roducers. Therefore, the objective of this study was to determine the optimum umber of livestock auctions in West Virginia which would be necessary to mini- ize the total cost of marketing (transportation plus selling costs) given the xisting annual volume of livestock sold in the State. Another objective was to etermine how large each of these auctions should be, in terms of annual sales, nd where they should be located, given 15 of the existing West Virginia auctions potential auction sites. Results were determined for three different levels of ansportation costs and three different levels of annual marketings of livestock.

A series of interviews with livestock producers, auction market owners, and xperiment station personnel determined that a relatively large proportion of vestock producers in West Virginia transport their livestock to market in /2-ton farm trucks. The computer model used in this study first determined the ptimum number, size, and location of auction markets in West Virginia based n the assumption that all farmers in the State transported their livestock to arket in 1/2-ton trucks. Fifteen of the 18 counties where auction markets are cated at the present time were chosen as potential auction market locations for xamination by the computer model. Of the 15 potential locations, only 13 ere required for total marketing cost (transportation plus selling) minimization. he cost per animal unit transported to these 13 optimal auction locations was 3.95.

[5]The auction areas and locations in Figures 3, 4, and 5 can be compared to the production ensities in Figure 2.

Another run of the model assumed all animals in the State would be transported by 1 1/2-ton fully loaded trucks. The cost figure for this truck was used to approximate the cost of hiring outside livestock transportation. In this case, only six auction markets were required for total marketing cost minimization. The average distance each animal unit had to be transported was longer since fewer markets were assumed to be available, however, the lower cost associated with the larger, more efficient truck compensated for the extra distance. The cost of transporting an animal unit to the six optimal auction locations in 1 1/2-ton trucks was $1.38.

The costs of selling livestock were also determined for these two situations. In the first case, when the 1/2-ton truck was assumed to be used, it cost $3.31 for each of the 13 auctions to sell one animal unit. When the 1 1/2-ton truck was assumed to be used, the six optimally located, larger auctions incurred a cost per animal unit sold of $2.65.

As can be seen from these data significant cost savings by both livestock producers and surviving auction market operators could result from more efficient use of transportation facilities. A significant decline in the number of auction markets could also result in higher livestock prices due to larger, uniform lot sizes which many buyers desire. However, there are more facets to the problem of the West Virginia livestock economy.

According to an earlier study,[27] the existing auction markets in the State are efficient, given the annual volume of livestock marketed. Seemingly, auction costs could not be reduced unless the annual volume of livestock marketed is increased and/or the number of livestock auctions in operation decreased. The average tarriff or fee for selling an animal unit was $3.49 in 1971. However, a simple average of the selling costs per animal unit in the existing West Virginia auction markets was $3.66 indicating a $0.17 average deficit.[28] The deficit indicated that the least efficient auctions operating in West Virginia would "...be forced out of the industry until the volume of livestock marketed through the remaining auctions increases to a point where..." cost per animal unit sold more closely approximates revenue per animal unit sold.[29] The present study found that marketing costs will be minimized with 13 auctions, assuming all animals are transported by 1/2-ton trucks. The average cost of selling livestock at this optimal number of auction markets could be reduced to $3.31. And if more efficient means of transportation were adopted, selling cost per animal unit could drop as low as $2.65 at six optimally located markets.

According to the 1969 Census of Agriculture, 52.2 per cent of the livestock producers in West Virginia sold less than ten head of cattle and calves per year,

[27] Kuehn, *op. cit.*, p. 38.

[28] *Ibid.*

[29] *Ibid.* p. 39.

nd 77.8 per cent sold less than 20 head per year.[30] This relatively large roportion of small-sized farms on an individual basis would not logically use the ıost efficient means of livestock transportation. Due to transportation costs, ach would prefer that an auction market be located as close as possible to the roducing farm. This preference would require a large number of auction market ıcilities in the State. However, the larger the number of auction markets in an ea with a given volume of livestock available for sale, the higher the selling osts incurred by auction operators. As explained previously, the least efficient uctions would be forced to cease operating until volumes increase enough in ıe surviving auctions to decrease selling costs. Therefore, the farmers' demand or more auctions has been an indirect cause of the decrease in the number of uction facilities. This development, however, would not seem to be the problem itself, because fewer auctions would incur lower per unit selling costs, llowing tariffs or fees to farmers to decrease. But transportation costs account or a larger proportion of the marketing bill and if more efficient transportation ractices are not adopted by producers, the increased distances required to ansport livestock to the fewer, more widely dispersed auction markets could crease the total cost of marketing livestock despite decreased selling costs. hese developments could result in lower farm income from livestock roduction in areas where similar conditions exist.

The prospect of lower farm income would logically cause a decline in the umber of small, inefficient farms. However, many of the livestock producers in 'est Virginia are part-time farmers. They may decide to continue producing vestock in spite of lower incomes from farming. Therefore, a decline in the umber of livestock farms due to low farm income could be retarded by the xistence of objectives other than profit maximization by some livestock roducers.

The trend in West Virginia toward fewer and larger livestock auctions robably will continue. Also, low incomes will induce some decline in the umber of small-sized, inefficient livestock producing farms and an increase in ıe number of larger, more efficient operations which are better able to utilize ore efficient marketing practices.

[30] 1969 Census of Agriculture, U. S. Bureau of the Census, Volume 1, Area Reports, Part i, West Virginia, Section 1, Summary Data, U. S. Government Printing Office, Washington, C., 1972, p. 5.

BIBLIOGRAPHY

Chern, Wen-Shyong and Leo Polopolus, "Discontinuous Plant Cost Functions and a Modification of the Stollsteimer Location Model," *American Journal of Agricultural Economics,* Vol. 52, No. 4, November, 1970.

Golden, Paul D. and John P. Kuehn, *Prices and Volumes of Livestock Sold in West Virginia Auction Markets, 1960-69,* WVU Ag. Exp. Station Bulletin 607, March, 1972.

Kuehn, John P., *Costs and Efficiencies of Model Livestock Auctions in West Virginia,* WVU Ag. Exp. Sta. Bull. 606, December, 1971.

Lin, Chen-fen and John P. Kuehn, *Livestock Transportation Costs in West Virginia,* WVU Ag. Exp. Sta. Bull. 613, January, 1973.

Polopolus, Leo, "Optimum Plant Numbers and Locations for Multiple Plant Processing," *Journal of Farm Economics,* Vol. 47, No. 2, May 1965.

Stollsteimer, John F., "A Working Model for Plant Numbers and Location," *Journal of Farm Economics,* Vol. 45, No. 3, August, 1963.

U. S. Bureau of the Census, 1969 Census of Agriculture, Volume 1, Area Reports, Part 25, West Virginia, Section 1, Summary Data, U. S. Government Printing Office, Washington, D.C., 1972.

U. S. Bureau of the Census, 1969 Census of Agriculture, Volume 1, Area Reports, Part 25, West Virginia, Section 2, County Data, U. S. Government Printing Office, Washington, D.C., 1972.

Wilson, Ewen M. and John P. Kuehn, *A Cost Analysis of the Livestock Auction Markets in West Virginia,* WVU Ag. Exp. Sta. Bull. 600T, April, 1971.

Appendix

APPENDIX TABLE 1

Optimum Sizes of Livestock Auction Markets in Terms of The Number of Animal Units Sold Annually and Selling Cost Per Animal Unit, Assuming Three Levels of Transportation Cost and a 25 Per Cent Increase in the Total Number of Animal Units Marketed

Location of Auction	Farm Truck (1/2-ton)		Half Farm Truck Half Hired Truck		Hired Truck (1 1/2-ton)	
	AU's Sold	Cost/AU[a]	AU's Sold	Cost/AU[a]	AU's Sold	Cost/AU[a]
Marshall	11,385	$3.90	11,385	$3.90	14,955	$ 3.79
Wood	16,674	3.46	16,674	3.46	–	–
Jackson	–	–	–	–	–	–
Roane	18,203	3.46	18,203	3.46	28,097	2.82
Mason	18,082	3.46	18,082	3.46	18,226	3.46
Lewis	23,102	3.06	40,807	2.55	56,100	2.51
Harrison	24,380	3.06	–	–	–	–
Marion	–	–	–	–	–	–
Preston	16,164	3.79	22,839	3.06	25,605	2.93
Randolph	13,399	3.75	13,399	3.75	–	–
Pocahontas	13,100	3.75	13,100	3.75	–	–
Greenbrier	36,730	2.60	36,730	2.60	62,963	2.45
Raleigh	14,727	3.79	14,727	3.79	–	–
Hardy	68,967	2.40	68,967	2.40	68,967	2.40
Jefferson	26,386	2.93	26,386	2.93	26,386	2.93
Total	301,299		301,299		301,299	
Average	23,177	3.08	25,108	2.97	37,662	2.69

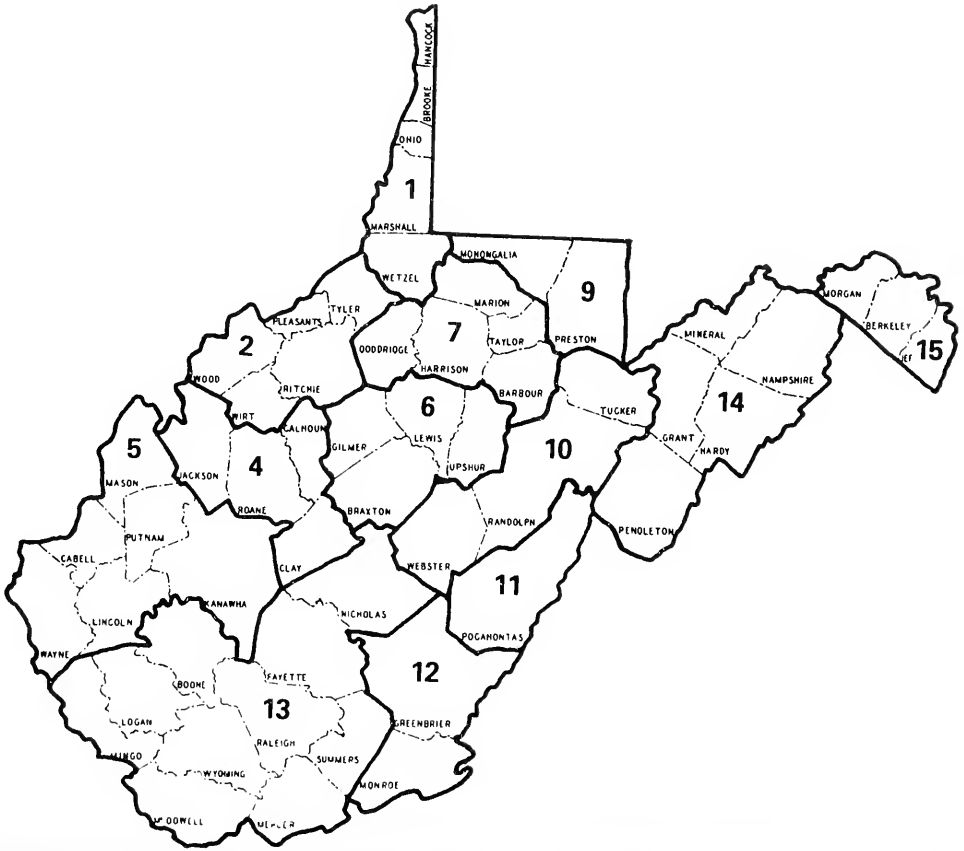
[a] sizes (in terms of annual number of animal units sold) to those in the optimum solutions of this study.

APPENDIX TABLE 2

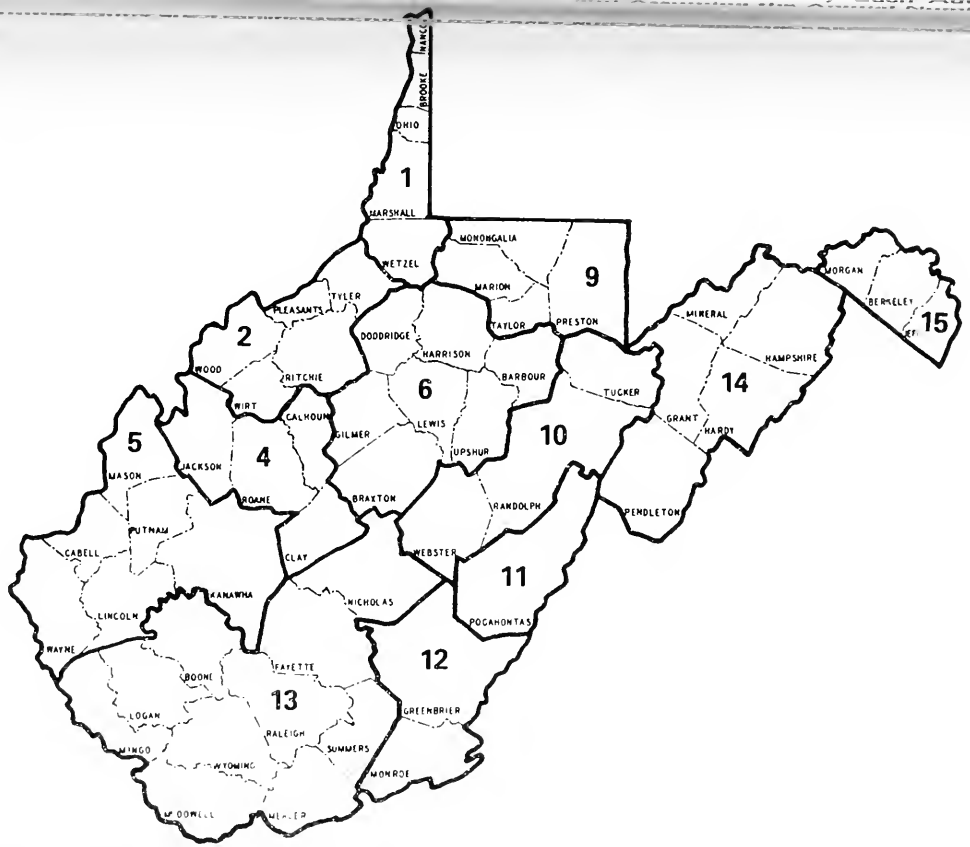
Optimum Sizes of Livestock Auction Markets in Terms of The Number of Animal Units Sold Annually and Selling Cost Per Animal Unit, Assuming Three Levels of Transportation Cost and a 25 Per Cent Decrease in the Total Number of Animal Units Marketed

Location of Auction	Farm Truck (1/2-ton)		Half Farm Truck Half Hired Truck		Hired Truck (1 1/2-ton)	
	AU's Sold	Cost/AU[a]	AU's Sold	Cost/AU[a]	AU's Sold	Cost/AU[a]
Marshall	6,831	$4.69	8,974	$4.27	–	–
Wood	10,005	4.12	–	–	–	–
Jackson	–	–	–	–	28,429	$2.82
Roane	10,923	4.00	15,989	3.79	–	–
Mason	10,849	4.00	10,849	4.00	–	–
Lewis	24,483	3.06	27,279	2.93	31,831	2.73
Harrison	–	–	–	–	–	–
Marion	–	–	–	–	25,529	2.93
Preston	13,703	3.75	13,703	3.75	–	–
Randolph	8,039	4.45	8,039	4.45	–	–
Pocahontas	7,860	4.45	–	–	–	–
Greenbrier	22,038	3.23	29,898	2.82	37,778	2.60
Raleigh	8,836	4.27	8,836	4.27	–	–
Hardy	41,381	2.55	41,381	2.55	41,381	2.55
Jefferson	15,832	3.79	15,832	3.79	15,832	3.79
Total	180,780		180,780		180,780	
Average	15,065	3.50	18,078	3.30	30,130	2.80

[a]The selling costs per animal unit were taken from Kuehn, *Ibid.*, p. 34. They are the total costs per animal unit sold in auction markets of similar size (in terms of annual number of animal units sold) to those in the optimum solutions of this study.

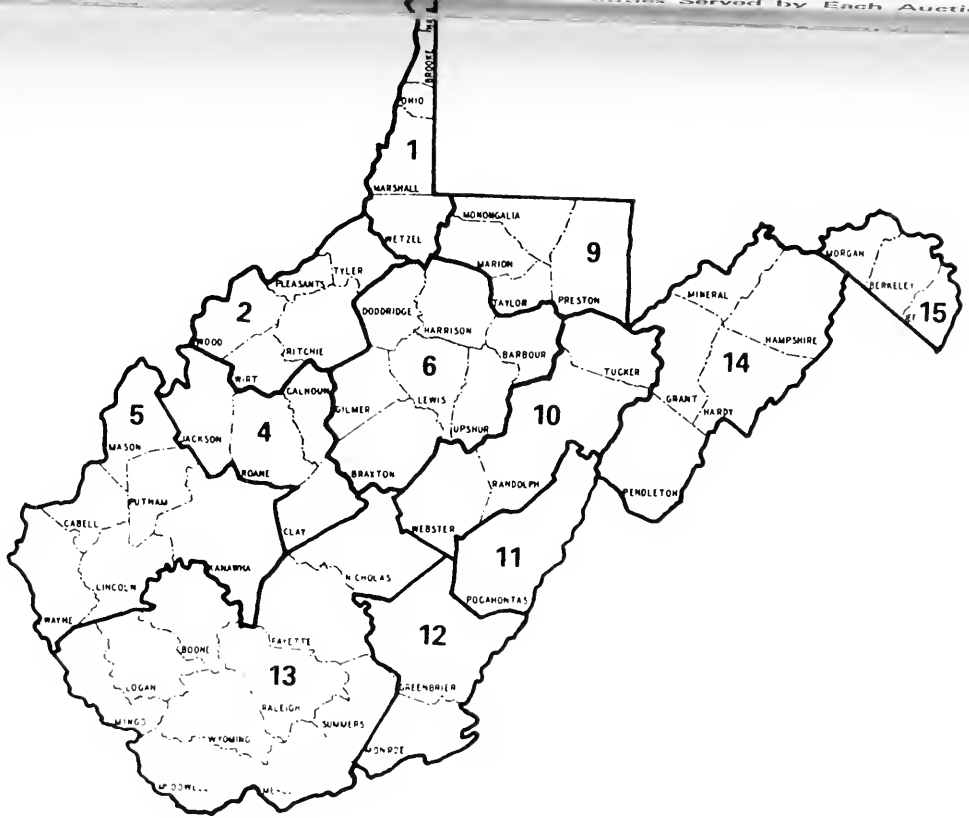


Appendix Figure 1. Optimum Market Locations and the Counties Served by Each Auction, Assuming all Animal Units are Transported by Farm Trucks and Assuming the Annual Number of

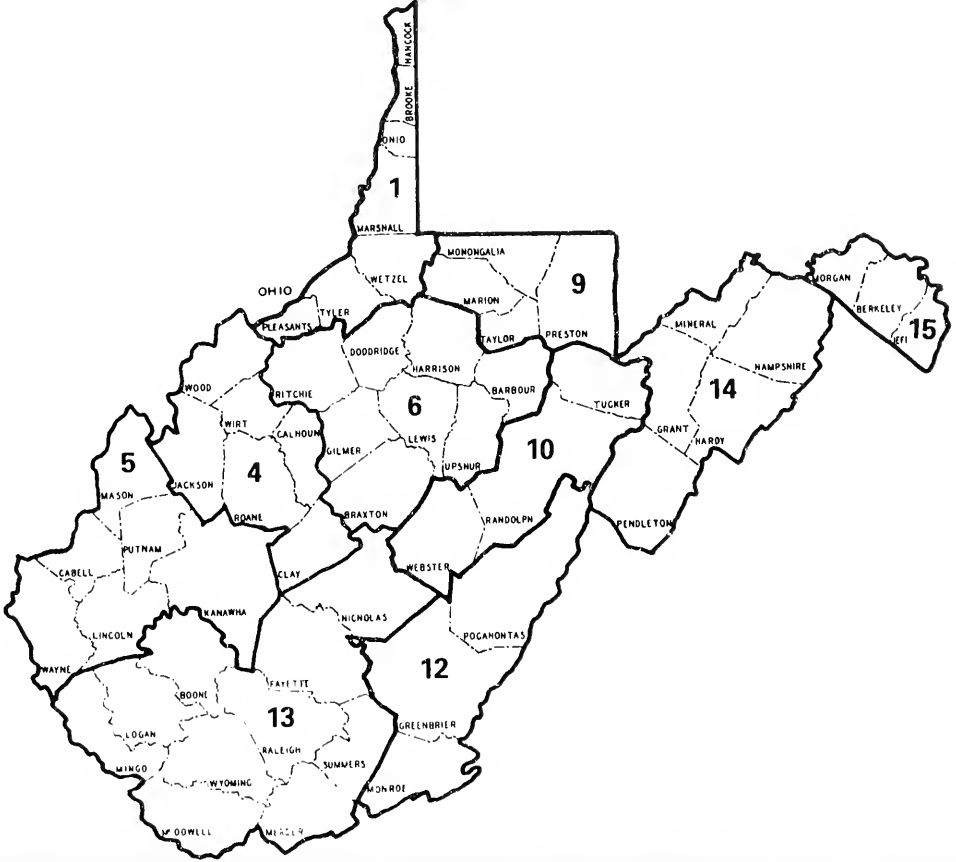


Appendix Figure 2. Optimum Market Locations and the Counties Served by Each Auction, Assuming Half of all Animal Units are Transported by Farm Trucks and Half are Transported by Hired Truck and Assuming the Annual Number of Animal Units Marketed

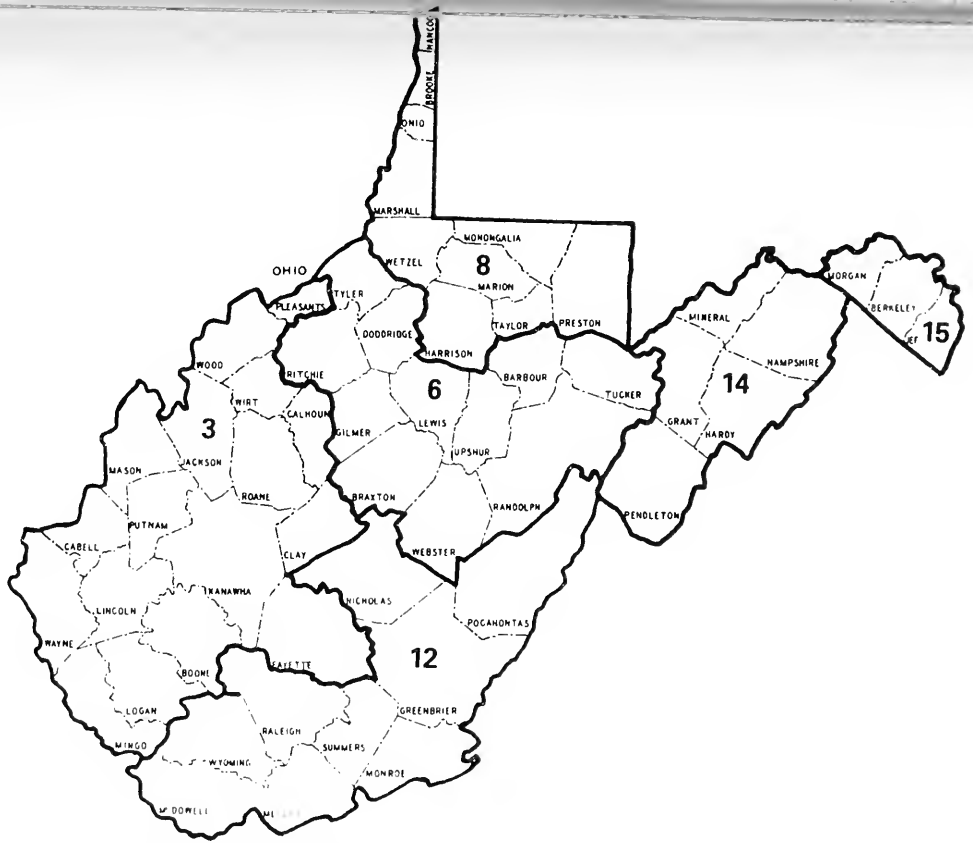
Appendix Figure 3. Optimum Market Locations and the Counties Served by Each Auction, Assuming all [illegible] Transported by Hired Truck and Assuming the Annual Number of Animal Units Marketed Increases 25 Per Cent



Appendix Figure 4. Optimum Market Locations and the Counties Served by Each Auction, Assuming all Animal Units are Transported by Farm Trucks and Assuming the Annual Number of Animal Units Marketed Decreases 25 Per Cent



Appendix Figure 5. Optimum Market Locations and the Counties Served by Each Auction, Assuming Half of all Animal Units are Transported by Farm Truck and Half are Transported by Hired Truck and Assuming the Annual Number of Animal Units Marketed Locally



Appendix Figure 6. Optimum Market Locations and the Counties Served by Each Auction, Assuming all Animal Units are Transported by Hired Truck and Assuming the Annual Number of Animal Units Marketed Decreases 25 Per Cent